FHP TECHNOLOGY DEVELOPMENT PROJECT PROPOSAL

Project Status: New, not previously funded.

Project Number: R6-99-02

Project Title: Developing Technologies for Early Detection and Predicting Occurrence and Spread of Yellow Starthistle (YST)

Subject: Weed prevention (Yellow Starthistle), detection and management of exotic weeds.

Project Objectives: To assess several sampling strategies and technologies for cost effectively locate YST infestations and to develop a predictive model to aid in finding naiscent infestations. A harard/risk rating process will be imbedded into this predictive model.

Brief Description: Control of noxious weeds on forests and range lands is simplified if "nascent infestations" or new populations are identified quickly, before native (or resident) vegetation is lost and weeds are able to build a reservoir of seed in the soil. Small, isolated YST populations are often relatively easy to control with small inputs of time, resources, and money. Unfortunately, small, isolated populations are very difficult to find. Weed monitoring and surveys can be prohibitively expensive and survey techniques are not well established. This project will develop methodologies to identify weed populations using an integrated approach that includes ground survey, remote sensing, GIS, and landscape modeling techniques. We will also compare methods to determine the strengths, weaknesses, and costs of each. The information generated from this project will be used to create alliances between landowners and prepare an integrated weed management strategy. The development of a model to predict the occurance and spread of YST will also occur with this project.

FHP Person Who Will Lead The Project: Don Goheen and Katy Marshall, Plant Pathologists, Southwest Oregon Forest Insect and Disease Technical Center (SWOFIDTC).

Justification: Yellow starthistle (Centaurea solstitialis L.) is an exotic that invaded in the early to mid 1800's as a contaminant of hay or seed. Since its introduction, it has spread to become one of the worst noxious weeds in California, Oregon, Washington and Idaho.

YST is currently out competing and displacing

native vegetation in numerous ecological provinces of the western United States. This constitutes serious forest and range health issues, especially in the Siskiyou ecological province which is one of the most floristically diverse areas west of the Mississippi. Current, ongoing studies with YST, include a R1 STDP project dealing with biological control, and a NAPIAP study looking at various chemical and mechanical control methods for YST. This proposal will build upon the R1 study and compliment the NAPIAP study, so a fully integrated IWM strategy for YST can be devised in SW Oregon.

Core infestations of starthistle or those areas in which weeds are prevalent are much easier to survey than are areas where weeds are represented by a few isolated and widely spaced individuals (nascent foci). Unfortunately, core infestations are often much more difficult and costly to control because YST can "charge" the soil seedbank quickly with hard seeds that germinate for the next ten years or more. Locating nascent infestations may, therefore, be far more important for control efforts.

One of our areas of concentration will be in the domain of weed survey. Weed surveys are done so scientists and managers can:

1. Determine the location of weeds for eradication and future monitoring.
2. Plan, optimize, and facilitate control efforts that use mechanical, herbicidal and biological agents.
3. Assess economic impacts of weed invasion and dominance on lands.
4. Determine which environments or sites are potentially subject to weed invasion
5. Determine invasion dynamics and the mechanisms by which weeds spread.
6. Develop predictive models so that sites which may have been invaded can be more easily identified to reduce search time for new invasion loci.
7. Better understand the biology and ecology of weed species to improve control efforts.
8. Increase public awareness, education, and coordination between land managers.

Urgency: YST is expanding its range is southern Oregon and northern California, moving into higher elevation zones and valleys previously free of this weed. YST poses a significant threat to ecosystem integrity. This plant is tap-rooted and can grow throughout the summer which means it is a strong competitor with native perennial vegetation. Sites that today contain a mixture of perennial grasses and exotic annual grasses will probably be converted to exotic communities, if YST invades. In addition, other perennial native plant communities are being threatened by YST. Managers need to be able to identify new populations of yellow starthistle quickly and inexpensively, so these populations can be controlled. Yellow starthistle is expanding its range into higher elevations and native

perennial-dominated ecosystems. Both private landowners and Federal managers need to locate this weed quickly if it is to be controlled and native plant populations are to be preserved. We believe a combination of remote sensing, GPS and GIS technologies can reduce costs, improve efficiencies and facilitate control strategies.

Link to National FHP Technology Development Priorities: This proposal addresses the 4th priority of the national STDP Steering Committee - Proposals that deal with detection, analysis, and management of exotic pests including exotic weeds that result in technologies or methods that contribute to our ability to prevent introductions or detect and eradicate new introductions. This proposal also addresses yellow starthistle, which was identified as a regional priority and Forest Health Restoration which is embedded in the National Resource Agenda.

Scope of Application: Initial scope is for Southwest Oregon; however, we expect be able to extrapolate this technology state-wide and to other species of exotic weeds. The possibility also exists to apply both technology and model to other states as well, including Washington, Idaho and California.

Research Basis: Three photographic overflights of sites infested with YST were done on the Rogue River NF and adjacent lands between September 1997 and August 1998. Coupled with ground-based photography taken of YST periodically throughout 1998. YST was indistinguishable from surrounding annual vegetation in aerial photographs taken in the late summer/fall and in the spring. Late summer/fall YST was light colored, as a result of thinning of the leaves (exposure of light soil surface) and appearance of yellow flowers. In the Spring, both YST and grasses were deep green color and could not be separated. However, there is a window of about three weeks in early/mid summer (June/July) between the time when annual grasses dry and when gray-green in color. Infestations are quite distinctive at this stage of development. We have not quantified the minimum size of the infestation detectable, optimal scale, or identification (misclassification) errors for aerial photographic techniques. At this time, it seems likely that infestations with a diameter of several meters will be detectable, which would permit the technique to be used with fixed-wing aircraft covering large areas.

Both natural (fire) and anthropogenic disturbance (roads, off-road vehicles, transport of hay, and heavy grazing) have been implicated with the spread of YST (Borman 1989, Borman et al. 1990, Issacson 1998, Whitson et al. 1992.) Landscape or watershed scale patterns of movement and dispersal have not been documented.

Survey information is generally compiled into maps showing weed distribution and the relative severity of the infestation across the landscape. Mapping simplifies communication between people working with weeds especially those implementing control measures. It will also facilitate understanding of the invasion process, starthistle biology and ecology.

YST monitoring involves repetitive sampling or examination of historical

documents, such as county weed records, herbaria records, or aerial and ground photographs. This provides a temporal perspective which leads to an appreciation of YST's populations dynamics. Sequential surveys and their resultant maps will define expansion or contraction rates for both yellow starthistle and associated plant communities, permitting evaluation of control efforts and projections of future impacts.

Yellow starthistle typically invades open grasslands and shrublands and is intolerant of shade which makes it a good candidate for detection by remote sensing. Forested areas that have burned or grassy patches within the forest can be invaded rapidly if seed exists on the site. Yellow star thistle expansion is closely linked to anthropogenic and natural disturbance as well as roadway corridors. Because this annual weed produces two types of seed, plumeless (that reinfests the area under the plant) and plumed (that is easily transported by vehicles, animals, wind and water), distribution tends to be clumped. In two to three years, an infestation several meters across is common. We believe that control of these nascent populations can considerably slow the spread and impact of this weed. Control measures are being developed that could improve our ability to manage yellow starthistle in the future.

Our preliminary work has indicated YST has a distinctive spectral signature in early summer, after annual grasses and forbs have aged and before star thistle blossoms. At this time, infestations with a diameter of several meters can be identified from fixed-wing aircraft or helicopters. We believe that a study employing systematic sampling and error assessment (including confusion with other plant species) will define potentials and lead to improved detection and control.

Mapping and monitoring noxious weeds using remote sensing was also investigated in central Idaho (Varner, 1997). Susceptibility modeling, data acquisition and image interpretation were examined. Timing of data acquisition was most critical and will constrain our window of opportunity. We will implement the use of both color infr-red and natural color photography in this project. Vicki Varner (personal communication, 1998) mentioned this as a possible enhancement to her work.

Detection of YST and common St. Johnswort with multispectral imagery was also investigated in Idaho (Lass, 1996). They found spectral measurements which indicated the radiance signature of YST to be distinctly different from associated plants. We will build upon this evidence and feel there is a high probability we can distinguish YST from our local associated plants on the Rogue River NF.

Methods: Locating Yellow Starthistle Within the Target Area - This project will statistically compare weed maps of a test area that are generated from a number of methods (locating both core infestations and nascent populations) for their cost and accuracy.

We will perform a 100% cruise of a target area where methods will be compared to

identify YST infestations. Weed occurrences will be geographically tagged, so that existing USFS vegetational, environmental, geographical, climatic, and cadastral GIS data themes can be used characterize sites that have a high probability of an invasion, native plant communities at risk, and areas that should be closely monitored. Data collected will improve our understanding of the process and rate at which YST invasion occurs and facilitate the development of a predictive model for locating nascient loci of YST on the landscape. For example, we may determine by looking at distribution overlays that south facing slopes are more likely to be dominated by yellow starthistle than are the cooler north facing slopes with denser perennial vegetation. Weed survey strategies could then be adjusted and priority given to lands with a southern aspect.

After our 100% cruise is completed, we will compare the following survey methods performed by new surveyors:

1. Sighting Reports

The easiest means of conducting a yellow starthistle survey is to ask people to note and report any sightings of weeds observed during their normal daily activities. We will ask county, state, and federal government employees, technicians, landowners, and interested private citizens to report sightings of yellow starthistle and other target weeds in a cooperative effort to map infestations within the cruised areas.

Because we know that the search for weeds will not be systematic or uniform across the landscape, coverage of lands will most likely be spotty with areas near roadways or work sites better documented than outlying lands. This can lead to false security because areas without sightings are assumed to be weed free. In actuality they may have significant weed populations which were never surveyed. A second problem with this type of survey is that starthistle may not be reported because surveyors do not actively search for it. The survey is sometimes perceived to be of relatively low priority and secondary to other jobs. In this framework, surveyors often miss occurrences close to their work sites simply because they haven't taken the time necessary to search. The third problem is related to weed identification. Although we don't expect this problem with yellow starthistle, weeds may not be reported because they are not correctly identified.

In spite of these limitations, sighting reports may be a good index to the relative severity of infestation of a region and may be very useful when coupled with other survey methods.

2. Systematic Weed Survey

Random Sampling: We will conduct systematic surveys of yellow starthistle across the target landscape in Jackson County. This should permit inferences to be drawn and predictions to be made regarding the full

distribution and impact of YST in the target area. We will divide the area to be sampled into units and methodically examine random units for weed presence. The sampled areas will be relatively small, permitting selection of sampling locations from random coordinates.

Stratified Random Sampling by Vegetative Community and Soil Type: We will also test a stratified random sampling technique for its efficacy across a landscape. Stratification will be based upon vegetation and soil type (strata). Sites to be surveyed will be determined by randomly selecting a number of grid sections within each stratum. The number of cells sampled will be determined by the relative area in that unit. If for example, soil type A is twice as extensive as soil type B then it will have twice as many sampled units.

Belt Transects: Within each randomly chosen cell we will establish belt transects that cross the landscape and sample it uniformly. A technician will walk each of the transects to locate weed occurrences. We will record the extent of the infestation recorded as polygons using GPS coordinate points on maps and estimate weed density. In this fashion, areas of infestation will be found, positioned, and quantified by vegetation and soil type.

Stratified Random Sampling by Distance from Disturbance (Roads and Power line Corridors): Because we know that YST is more prevalent near disturbance features (DF) on the landscape we will test a random sampling procedure in which areas close to disturbance are more heavily sampled. A map of the target area will be generated with disturbance features outlined and buffers created that divide the area into units within 25m of disturbance, 26-100m, and >100m. Areas closest to disturbance will be sampled at 4 times the level of distant areas. Intermediate areas will be sampled at twice the intensity of distant areas.

We will work with the OSU Department of Statistics or USFS Statisticians to optimize the sampling strategy and minimize cost, as a "sequential sampling" approach may be desirable. Dr. David Thomas or one of his colleagues at OSU will be a cooperator on the project and assist in the statistical sampling design.

3. Remote Sensing

We will use two sources of remote sensing information, satellite images and aerial photographs to assist us in locating yellow starthistle infestations. Remote sensing technology has rapidly evolved during the last several years. Computer software packages that permit the manipulation of radiographic, photographic, and video graphic images have provided unprecedented power to remote sensing specialists. Data can now be acquired, processed, and output in several formats at a variety of scales.

Satellite Remote Sensing: Satellite images have found only limited

usefulness for weed surveying but it has been used for predicting sites that may be subject to weed invasion or those where invasion is unlikely (Dennis Isaacson and his associates with the Oregon Department of Agriculture). This application assumes that ground vegetation with similar spectral signatures is analogous in structure and therefore has similar environmental parameters. Although we believe that satellite imagery is too broad for locating yellow starthistle and that it has limited chance for success in predictive modeling, we will examine existing Landsat TM data to determine if there is a relationship between spectral classes and sites that have been invaded by yellow starthistle.

Fine Scale Monitoring using Remote Sensing: Fine scale monitoring of yellow starthistle will be accomplished using low altitude aerial photography verified with ground measurements. Transects will be photographed in July at two scales (1:6000 to 1:1000) to determine if infestations can be identified and at what size they are first discernible. Both color and infrared photographic films will be used. If identifiable, infestations will be monitored over time by repetitive overflights spaced at yearly intervals to identify rate of spread in various plant associations. Aerial photographs will be processed using automatic computer based algorithms, as well as, manual photo interpretation techniques in which a trained technician will identify areas of weed infestation by color, pattern, texture, site, size, shape, etc. Output will consists of georeferenced maps of observed weed distribution and calculated surface area of infestation. The spatial scale to be covered will vary somewhat depending on the techniques being employed. The test area for sighting reports, systematic weed survey, satellite remote sensing and standard aerial photographic techniques will cover the watershed of the Little Applegate River and Applegate River above Ruch, Oregon. This area contains approximately 300 square kilometers with considerable variation in topography, soils, land use, land ownership and vegetation. It is large enough to test detection methodologies and remote sensing technologies, yet small enough for close examination. This area is also large enough to develop a predictive model that indicates sites with a high probability of invasion.

Fine-scale monitoring of yellow starthistle infestations using near-Earth remote sensing technologies will be conducted at several locations covering ten to twenty hectares. These sites will help us determine optimal pixel sizes and spectral bands for detection of yellow starthistle patches of various sizes and densities.

4. Predictive Models of Yellow Starthistle Distribution

We believe that starthistle patterns across the landscape will reflect the environmental and physical factors are controlling establishment. Factors such as distance from a known seed source, soil type, slope aspect, distance from roads or power line corridors, present vegetation, etc., control weed invasion and influence invasion patterns. Risk will be distinguished by:

1) identifying map areas that have specific combination of feature characteristics, and

2) mathematically combining factors using regression or other statistical techniques.

Obviously, any information that indicates sites that are at high risk will reduce the area that needs to be searched resulting in reduced costs and increased efficiency of labor. Use of this model should make surveys more efficient because searchers can concentrate on these locations. Surveys may be further improved by systematic examination of selected portions of these features near known infestations and a complete landscape-level map could then be generated by subsampling within land with various risk classifications.

We know that yellow starthistle has specific requirements for soil depth and strongly suspect that soil type, overstory vegetation, and elevation all play important roles. Records will be maintained for intensive study areas so that predictive models of yellow starthistle movement can be created and risk modeling can be attempted for native plant communities the Applegate Region.
A new area will be identified to test the usefulness of the predictive model.

Measure of Success:

1) Evaluation of YST distribution maps generated from sampling techniques to that of the map generated from the 100% cruise.
2) Evaluation of the cost of each method and the development of cost effective technology.
3) Extrapolation of predictive model state-wide and to other interested states (e.g., California, Washington, Idaho,etc.).

Cooperators:

Dr. Doug Johnson, Rangeland Science, OSU
Dr. David Thomas, Professor of Statistics, OSU
Mr. Randy White, OSU Extension, Medford, OR
Dennis Isaacson, Tim Butler, Ken French and Eric Combs, Oregon Department of Agriculture, Salem, OR
Paul Korbulic, Jackson County.
Native Plant Society, Jackson County.
Cattlemen's Association of Jackson County.

Products: The product of this research will be a thorough, documented, examination of several survey methods, the development of a predictive model of where yellow starthistle is likely to invade, and a map of starthistle populations on a target area within the Applegate landscape. This weed map will facilitate information exchange and cooperation. Locations of weeds, their

relative abundance and other observations will be identified by map coordinates or map overlays on an accurate base map.

Publication: Results of this project will be published in peer reviewed journals, scientific papers, and extension bulletins.

Technology Transfer: Technology transfer will employ the OSU Extension Service and USFS personnel. Training sessions, brochures, and training video, etc.will be used to transfer the technology developed by this proposal.

Project Duration: Four years.

Long Term Budget:

Estimated FHP Funding---

	FY99	FY00	FY01	FY02
Weed Survey Questionnaires	5,600	5,600	5,600	5,600
100% Ground Survey	12,000	12,000	12,000	12,000
Aerial Photography	11,000		11,000	
Satellite Imagery	4,000			
Model Formulation	4,000	4,000	4,000	4,000
Comparison of Maps for Error Matrices	2,000	2,000	2,000	2,000
Tech Bulletin Video Prod		15,000		
Home Page	500	500	500	2,500
Total	39,100	24,100	50,100	26,100

FY99 Budget Request:

	FHP	Other*
Equipment to be purchased:		3,600
Contracting: Aerial Photography		11,000

Satellite Imagery	4,000
Salary:	16,000
Overhead:	2,000
Travel:	2,500
Total FY 1999 request	39,100

* Other cooperators include (list names, affiliations, and contributions. For non-FID cooperators, describe the project role, financial and personnel contributions, and time commitment of each.)

Oregon Department of Agriculture--Technical advice, biocontrol agents, sound bite development, and Technical Bulletin development. 1 week per year. Dennis Isaacson (retired), Tim Butler, and Ken French.

Medford, District of the BLM--Personnel, research sites. 1 week per year. Nabil Atalla and Bob Budesa.

Jackson County--Labor, research sites. 2 days per year, as needed. Paul Korbulic.

OSU/Local Extension Service--Technical assistance, site selection, data analysis, technical bulletin development and video development.
1 month per year. Doug Johnson, OSU and Randy White, OSU Extension.

Native Plant Society--Labor. 1 week per year, as needed. Wayne Rolle and Barb Mumblo.

Cattlemen's Accociation--Labor, research sites, animals. 1 week per year, as needed. Jeanette Williams, contact.

STDP PRODUCTION FUNCTION

PROJECT NUMBER: R6-99-02

PROJECT COST: $139,400

Year	0	1	2	3	Total
STDP request	39,100	24,100	50,100	26,100	139,400

PROJECT OBJECTIVE (BRIEF DESCRIPTION OF THE PROJECT AND EXPECTED OUTCOME):
Developing Sampling Technologies for Early Detection of Yellow Starthistle. Detection technology and YST model are used and as a result, 90% of new infestations will be contained or eradicated.

ASSUMPTIONS:

* With early detection technologies, we are able to locate 90% of new infestations.
* Early detected new infestations are small and therefore contained. Complete occupancy is retarded a long, long time.
* We ultimately find a combination of treatments (i.e., biological, cultural techniques, herbicides) to hold YST in check with early detection.
* The above is NOT the case without early detection.
* Without early detection 10-25% of the new infestations are detected within 5 years.
* Treatment costs are estimated to be $30 per acre with or (more?) without early detection.
* Analysis will be truncated at 5 years.

The following assumptions are the result of personal conversations with Dennis Isaacson, Program Supervisor, Noxious Weed Control, Oregon Department of Agriculture, and Steve Bulkin, Forest Silviculturist, Rogue River NF:

* Without early detection we can expect 100% occupancy within 40 years.
* With early detection we can expect only 10% occupancy within 40 years.
* Without early detection 50,000 acres will be treated annually.
* With early detection 6,000 acres will be treated annually.

References Used by Dennis Isaacson:

Roche, Ben F. 1993. Status and Trend of Weeds of the Centaurea Complex in Oregon. In Knapweed Newsletter, October 1993, Volume 7, No. 3. Washington State University, Pullman, WA.

Isaacson, D.L. et. al. 1996. Biological Control in the Management and Spread of Invasive Weed Species. In Proceedings of the IX International Symposium of Biological Control of Weeds. pp. 27-31. V.C. Moran and J.H. Hoffman (eds). 19-26 January 1996, Stelienbosch, South Africa, University of Cape Town.

BACKGROUND DATA:

* There are no outside costs for this proposal.
* Treatment costs are estimated to be $30 per acre with or without this proposal. Benefit category is primarily the avoidance of restoration costs; however, the following intangible benefit categories also apply:
  - Avoid pesticide related costs.
  - Increased Forage Production.
  - Maintain Wildlife Habitat.
  - Protect Threatened and Endangered Habitat.
  - Avoid Threatened and Endangered Species Listings.

CALCULATIONS

EXPENDITURE & OUTPUT VALUES (EOV) WITHOUT PROJECT:

($30/ac treatment) * (50,000 ac) * (4.45) = $6,675,000
(Pg 19, method 3) Analysis truncated at 5 years.

EXPENDITURE & OUTPUT VALUES (EOV) WITH PROJECT:

($30/ac treatment) * (6,000 ac) * (4.45) = $801,000
(Pg 19, method 3) Analysis truncated at 5 years.

BENEFIT (CHANGE IN EOV) ATTRIBUTABLE TO PROJECT:
B = $(without) - $(with), as this is a cost reduction project
B = $6,675,000 - $801,000 = $5,874,000

BENEFIT/COST RATIO:
B/C = $ (with) - $ (w/o)
$ (STDP cost) + $ (treatment cost, where applicable)

(pg. 18, method 2) B/C = 44.65

Yr	Project Cost	(Discount factor)	
0	39,100	1.0	39,100
1	24,100	0.96	23.136
2	50,100	0.92	46,092
3	26,100	0.89	23,229

Total Discounted Costs 131,557
Change in EOV/ Disc Cost = 5,874,000/131,557 = 44.65

BENEFIT ATTRIBUTABLE TO STDP:
Benefit attributable to STDP funds = $ (STDP cost) x (B/C)
($131,557) * 44.65 = $5,874,000

PNV OF PROJECT:
PNV of project = $(Benefit) - $(cost) No outside costs
= $5,874,000

PNV OF STDP:
PNV of project = $(Benefit attributable to STDP) - $(STDP cost)
= $5,874,000 - $131,557 = $5,742,443

Literature Cited:

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satellite data to map false broomweed (Ericameria austrotexana) infestations on south Texas rangelands. Weed Technol. 7:865-871.

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Literature Cited (continued):

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